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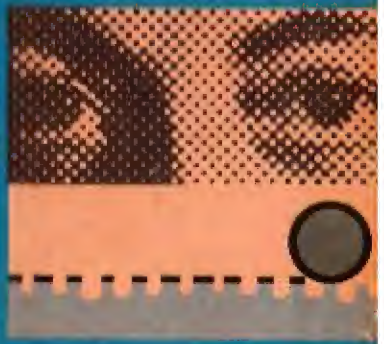
'How it works'

PRINTING PROCESSES

A LADYBIRD BOOK



In spite of the importance of radio and television in our daily lives, printing still provides the strongest, most lasting means of communication known to man. This book, with its explanatory text, diagrams and illustrations, tells as simply as possible how printing and its allied processes work. It will be of interest to children or adults wishing to know something about these far-reaching subjects.

The Publishers wish to acknowledge the assistance given, in the preparation of this book, by the following: The Monotype Corporation, The Linotype Corporation, The Heidelberg Manufacturing Co., Price, Service & Co., Ltd.

A Ladybird Book
Series 654

INDEX

'How it works'

PRINTING PROCESSES

by DAVID CAREY
with illustrations by B. H. ROBINSON

Publishers: Ladybird Books Ltd . Loughborough

Printed in England

The Main Printing Processes

Although, in this modern age, we may think of television and radio as the main means of mass communication, printing still provides the greatest source of news, information and knowledge known to man. Not only do we read newspapers, magazines and books of all kinds but we must have labels to tell us what is inside a bottle, tin or package, what music is recorded on a disc or written on a sheet, even what programme is on the radio or television. In fact, printing enters into every aspect of our daily lives. Just think about it and you will realise that this is true.

There are several different printing processes, and one or more variations of each. Each process has its own special advantages and limitations. In this book we shall take a close look at the whole subject, but first let us see what are the three most important methods.

Letterpress printing is carried out from a raised surface. *Lithography*, or litho, to use its more common name, involves printing from a flat or very slightly recessed surface. *Photogravure*, normally shortened to gravure, is printing from a recessed surface. This process is also known as *intaglio* printing. (The word comes from the Italian and means 'to cut into'.)

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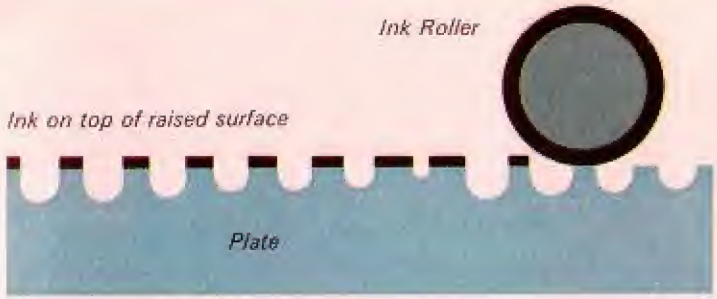
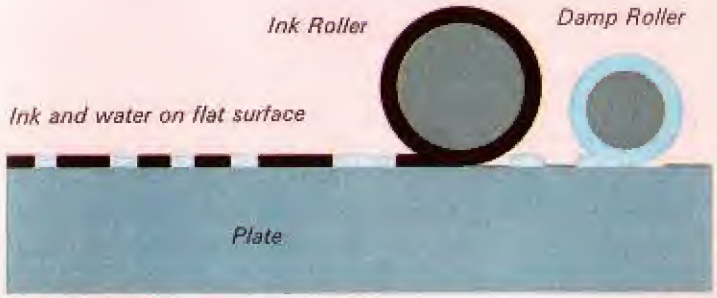
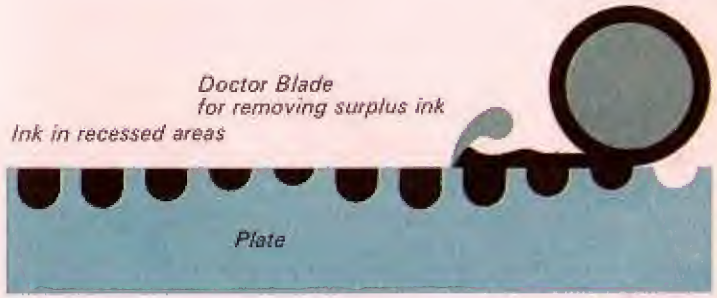


The Letterpress principle



The Photo-Lithography principle



The Photo-Gravure principle

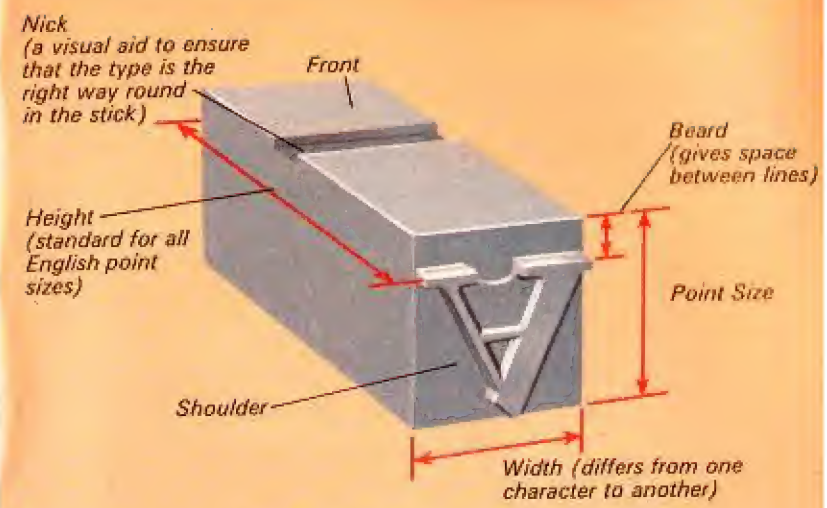
Setting the Type

When movable type was first invented in the mid-fifteenth century, all the separate pieces were kept in two cases, one above the other*. The upper case always contained the capital letters and the lower case held the small letters. Capitals thus became known as upper case letters and the small type as lower case, and this terminology is used in printing even today.

Type was always set by hand, one letter at a time being placed in a narrow tray, known as a *composing stick*, which was held in the other hand. By moving a slide along the tray and fixing it in the desired position, the lines of letters could be set to a precise width. Most type-setting today is done by machines which do the job very quickly, but the composing stick is still used when a small amount of setting has to be done, such as display headings, for corrections or when there are a number of different sorts and sizes of type to be set.

The man who sets the type and composes the page is called a *compositor*. Type letters are made the wrong way round so that they will reproduce the right way when printed onto paper. Hold some printed matter up to a mirror and you will get a compositor's eye view of the type.

* *See the Ladybird book 'The Story of Printing'.*



Parts of the Type

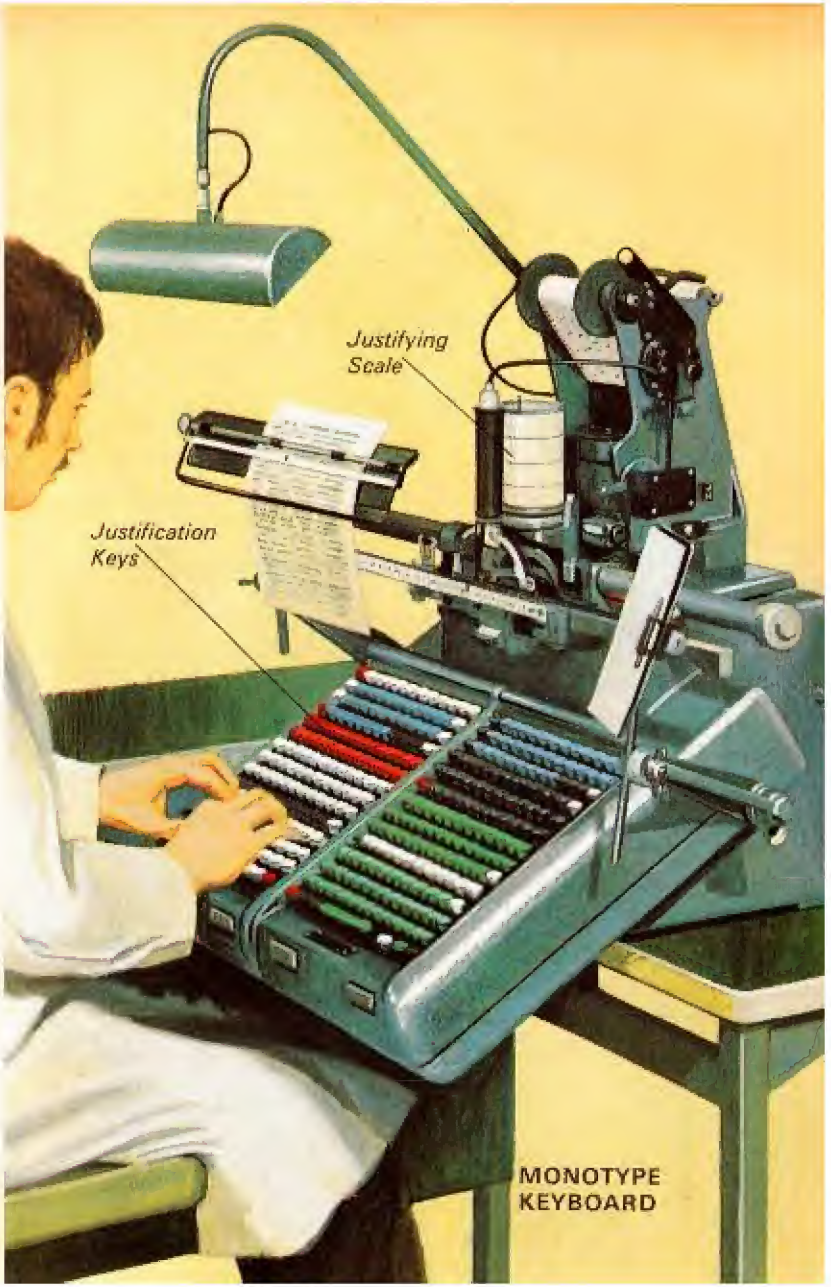
Type in the Composing Stick

Mechanical Typesetting

Machines for setting and casting metal type have been in use since the late nineteenth century. There are two main kinds used today: *Monotype* by which the characters are cast individually, one at a time, and *Linotype* which casts a complete line in the form of a type *slug*.

Although the two machines are really quite different in operation they both have keyboards containing all the necessary upper and lower case characters, figures, punctuation marks, spaces and so on. The operator presses the appropriate keys on the keyboard and this sets the various mechanisms in motion.

Apart from the normal type keys, the keyboard also includes what are known as *justification keys*. Usually on a printed page, like the one you are now reading, the lines of type end evenly, each line being of exactly the same length. In other words, the lines are *justified*. When the keyboard operator has nearly reached the end of the line he is setting, a justifying indicator tells him what space is left. He must then decide whether he can complete the last word or whether the line has to be justified. If the word is too long, he presses a justification key and this adjusts the spaces between the existing words so that the line is set to the exact measure required.



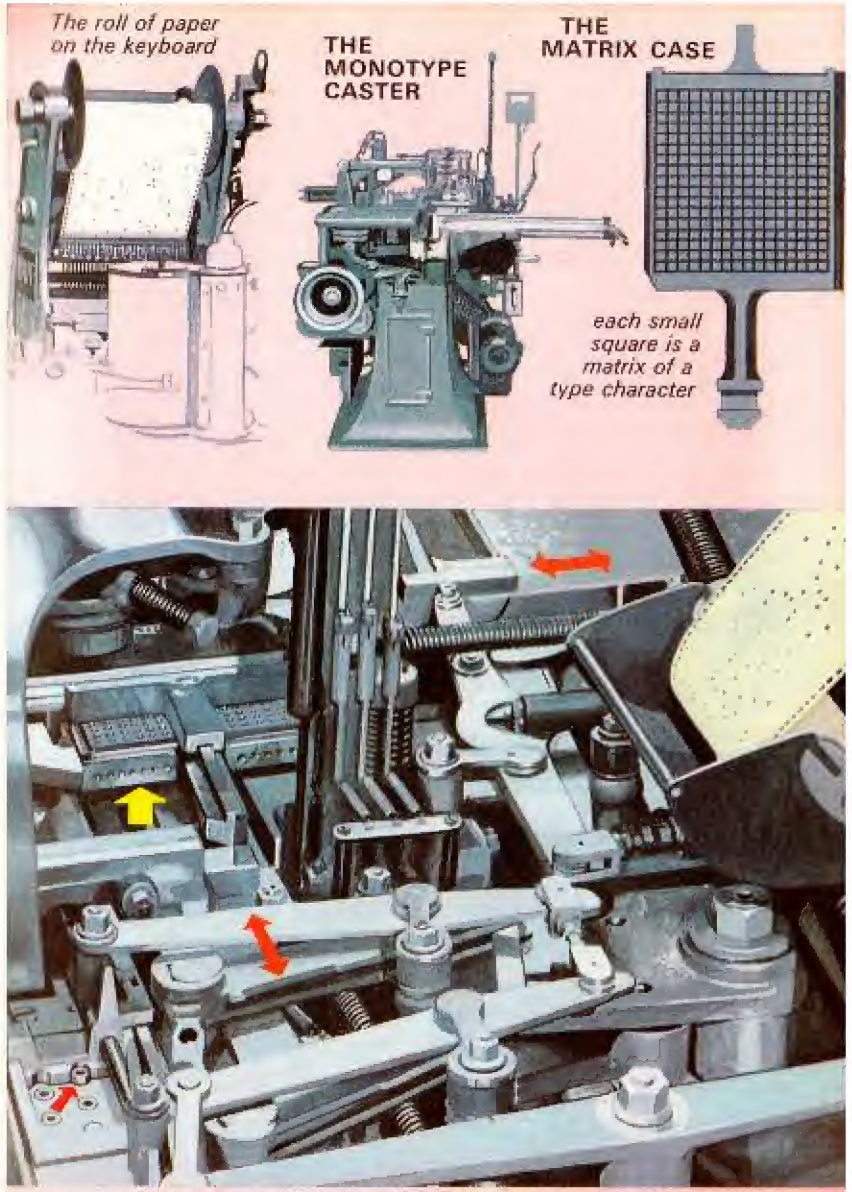
MONOTYPE KEYBOARD

The Monotype Process

Operating the keyboard of a Monotype machine does not immediately produce letters and words. What it does is to cause a succession of holes to be punched in a roll of paper mounted above the keyboard, each character being represented by a different arrangement of two holes.

Just below the paper is a series of air-operated punches. Every time a key is pressed two jets of compressed-air are released, two valves open and the appropriate two punches are made to perforate the paper. This happens for each character in turn until the keyboard operation is complete. The paper roll is then removed and transferred to the type caster, which is a separate machine and the one that actually makes all the pieces of type. Its functioning is entirely controlled by the perforations in the paper.

A pattern, or *matrix*, of every piece of type likely to be needed is contained in a matrix case which is put in place on the caster. As the perforated paper is fed through the machine it passes over a series of compressed-air pipes. Where every two perforations occur, jets of air are allowed to pass through. These raise pins which limit the movement of the matrix case, bringing the matrix for that particular character over a small hollow, or *mould*. Molten metal is injected into the mould; it sets immediately and a cast impression of the type is made.



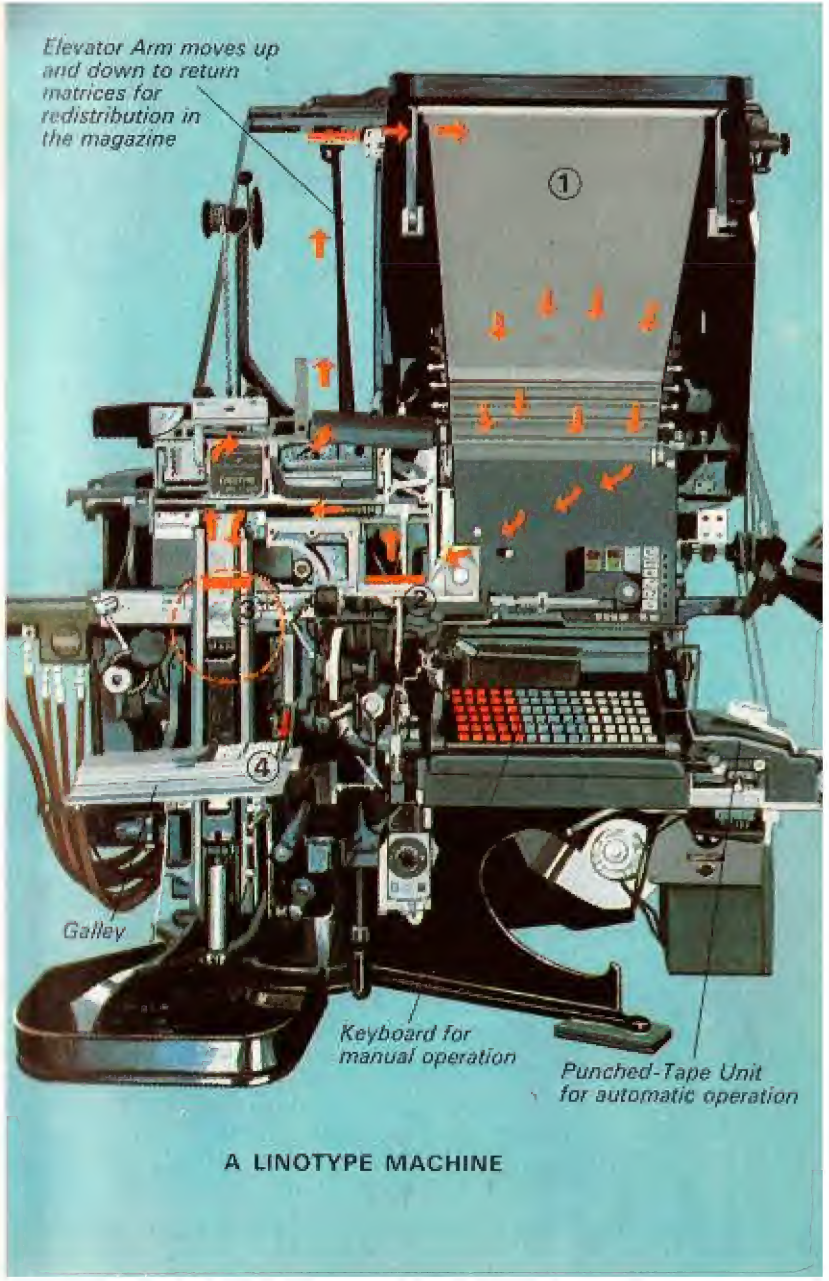
Rear view of the Caster showing perforated paper, the Matrix Case (yellow arrow) and the Mechanical Linkage (orange arrows) which moves it from side to side and from front to rear, and one of the Raised Stop Pins (red arrow).

The Linotype Process

Unlike the Monotype system, which has a separate keyboard and caster, the Linotype method combines both functions in the one machine. It is perhaps the more popular of the two, especially where a large amount of type-setting is needed, as in newspapers for instance.

Instead of a roll of paper above the keyboard, the Linotype machine carries a large matrix magazine (1). When a key is pressed the required matrix is ejected onto a conveyor which takes it to an assembly box where it is quickly followed by other matrices, shown as arrows on the illustration, to make up the words of a complete line (2). At the end of each line the keyboard operator moves a lever and the box of matrices passes in front of a geared wheel (3) carrying a number of moulds. The rotation of the wheel is timed so that as each line of matrices arrives, one mould will fit over it. Molten metal is pumped into the mould, and the line is cast in a slug of type which is ejected onto the galley (4). The next mould on the wheel fits over the next line of matrices and so the process is continued in a succession of rapid, casting operations.

The supply of matrices in the magazine is limited, so there is a device incorporated in the machine which sends each matrix back to the magazine to be used again as soon as the type has been cast.



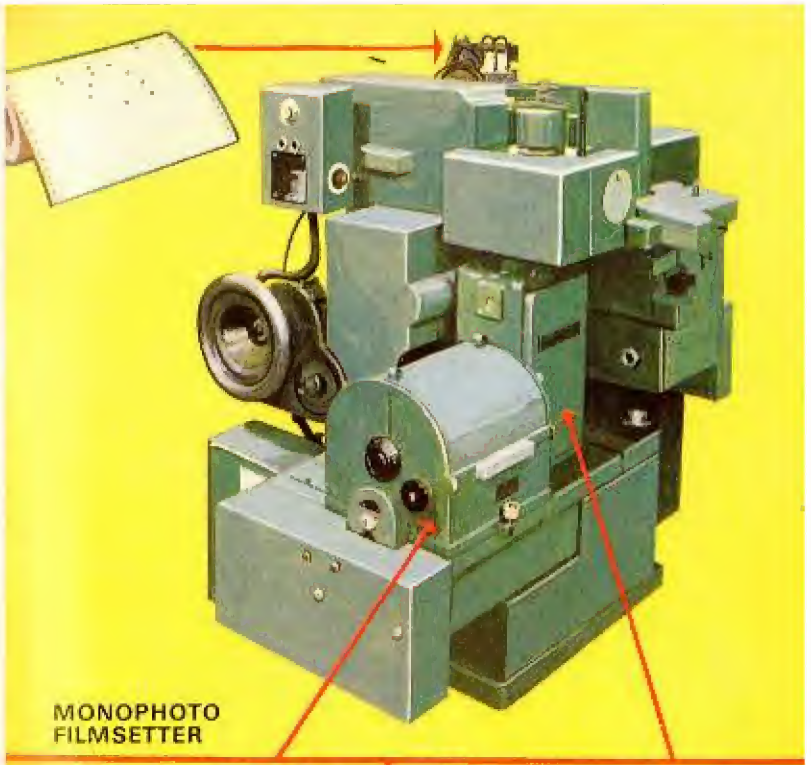
A LINOTYPE MACHINE

Film Setting

There is a third method of setting type and that is by means of photographic film. It is a process that has gained in popularity and use over the last few years. There are several makes of machine available, some operated electronically, but the one in most general use at the present time is the Monophoto Filmsetter.

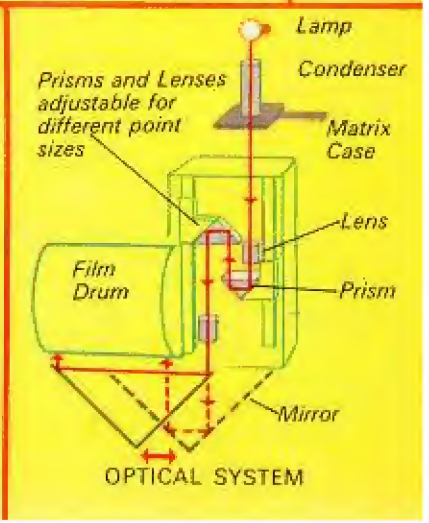
The machine retains some of the features of the Monotype system, described earlier, in that the operation of a keyboard causes holes to be punched in rolls of paper tape. However, instead of the normal matrix case and type caster, the system uses negative images of the type on pieces of film, contained in a film matrix case, which can be selected and reproduced photographically.

The paper tape is fed past air pipes as before, and the arrangement of holes, allowing air to pass through, controls the selection of the pieces of type film in the film matrix case. A beam of light is projected through the selected matrix and a positive image of the type is photographically printed on to a sheet of film material contained in a drum. The photographing is done through an arrangement of lenses and prisms, the adjustment of which enables the type image to be enlarged or reduced as required. As with type casting, film setting is carried out at quite fast speeds. The resulting film can be used for making letterpress printing blocks (see page 22) or lithographic printing plates (see page 40).



MONOPHOTO FILMSETTER

Loading the Film Drum



OPTICAL SYSTEM

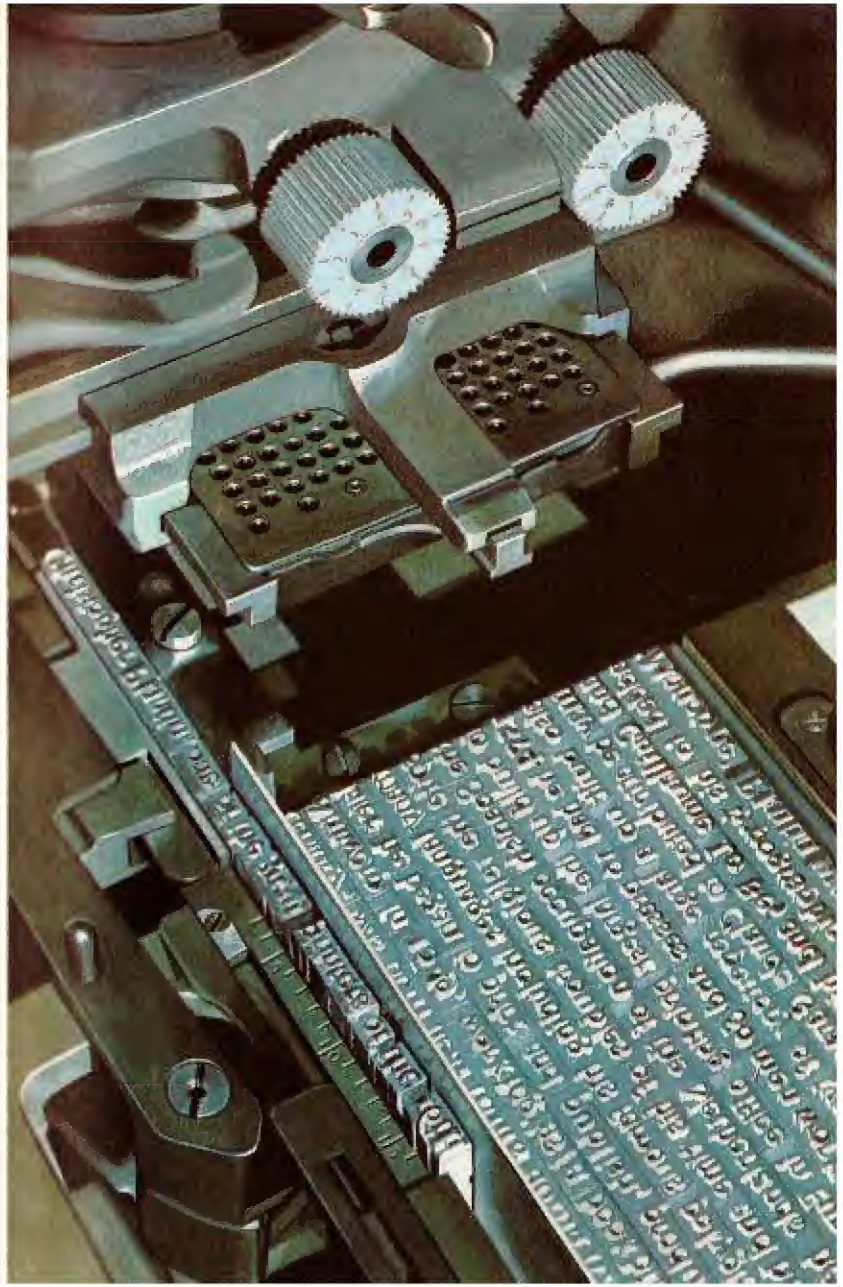
Galleys and Proofs

When each line of type has been produced by a type caster, it is ejected into a long, shallow, metal tray placed at the side of the machine. This tray is known as a *galley*. An impression, or *proof*, of the type in the galley is next printed on to paper. The paper is usually in long strips similar to the shape of the galley, and a proof of this kind is called a *galley proof*.

The galley proof provides a first opportunity for the type-setting to be checked visually, and the person who does this job is the *proof reader*. He is a very important member of a printing organisation and is skilled in finding any errors which might have been made by the keyboard operator, and any faults in the type itself. He checks the proof against the original text, or *copy*, from which the type was set and makes sure the setting exactly follows the original, letter by letter and word by word. Any errors he finds are noted with special marks so that they can be corrected by the compositor.

After galley proofing, the long strips of type are split up into page lengths and a further *page proof* is taken to make sure the original mistakes have been corrected and no additional ones have occurred.

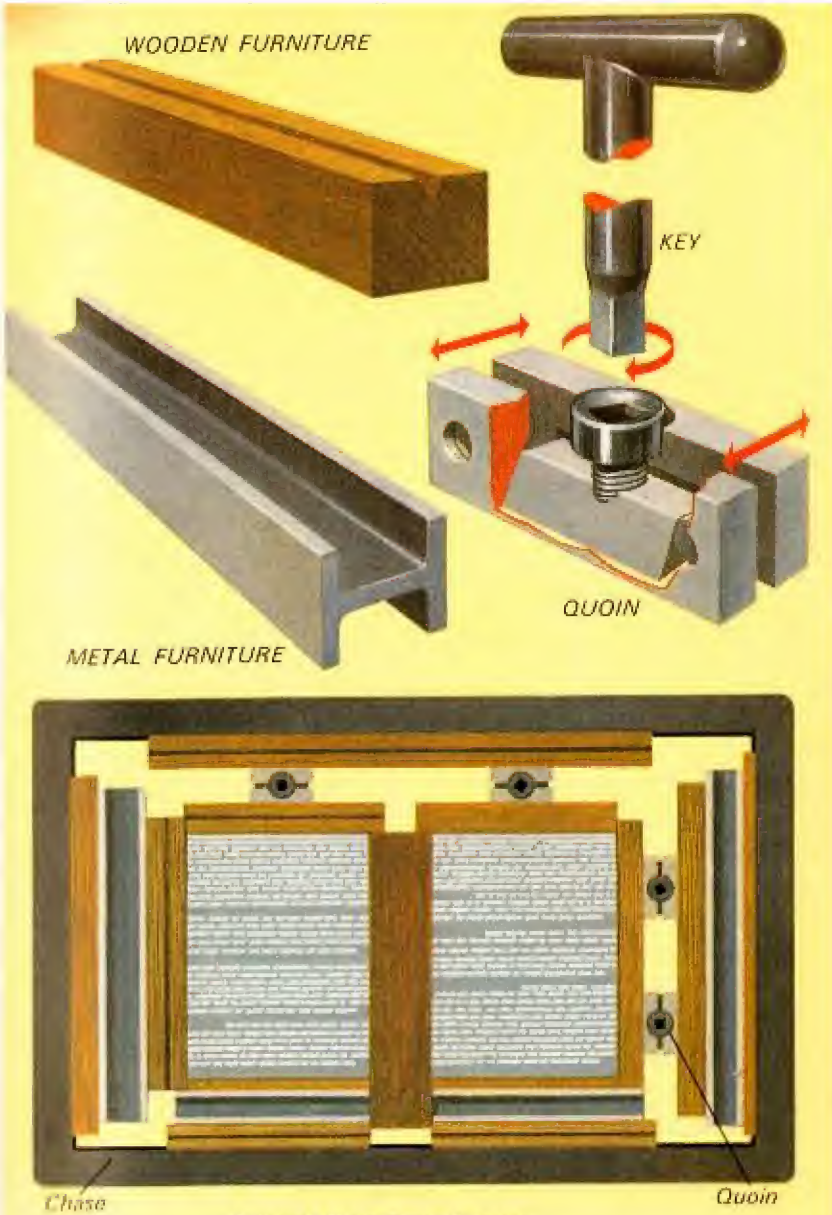
A line of type being ejected from the mould onto the galley at the rate of three characters a second.



Formes and Furniture

The pages of a book are not printed separately, one at a time, but on larger sheets of paper carrying four, eight, twelve or more pages on each side. The areas of type must be so arranged that when they are printed, and the sheets folded, the pages follow one another in their correct sequence. The arranging of the type in this way is known as *imposition*.

Imposition for letterpress printing is carried out on a big cast-iron table with a perfectly flat top, and the various areas of type are positioned within a steel frame known as a *chase*. *Furniture*, in the form of pieces of metal or wood, is inserted between the page areas of type and between the type and the chase to keep them the correct distance apart. Steel wedges, or *quoins*, are then tapped into position between the furniture and the chase, and finally tightened up by means of a key until nothing can move. This complete and now solid assembly of chase, type, furniture and quoins is known as the printing *forme*. After a last proof has been taken, as a final check, it can be put on a letterpress machine for printing.



A Small Two-Page Forme

Reproducing Illustrations—Letterpress Process

So far we have dealt with the basic facts about making, setting and imposing type, but what if the printed book, newspaper or magazine needs to include illustrations? This requires an entirely different technique which, for letterpress printing, is known as *process engraving* or *blockmaking*.

In printing terms there are just two kinds of illustrations, *line* and *half-tone*. With line blocks the printing surface produces a solid colour on the paper without any gradations of tone. In other words it is simply one colour or white without any shades of colour between. This kind of block prints well on even the poorest quality paper and is suitable for reproducing type-matter and pen-and-ink drawings.

Half-tone blocks are used to reproduce from subjects such as photographs or wash drawings in which the tones vary throughout the illustration. If you look through a magnifying glass at a photograph in a newspaper or magazine, you will see that it is broken up into a mass of dots. These dots are larger and more closely-packed in the dark areas, and are smaller, more widely-spaced in the light areas. Later in this book we shall learn how this dot formation is achieved. Generally speaking, half-tone blocks reproduce better on good quality paper, although the *screen* plays an important part in this.

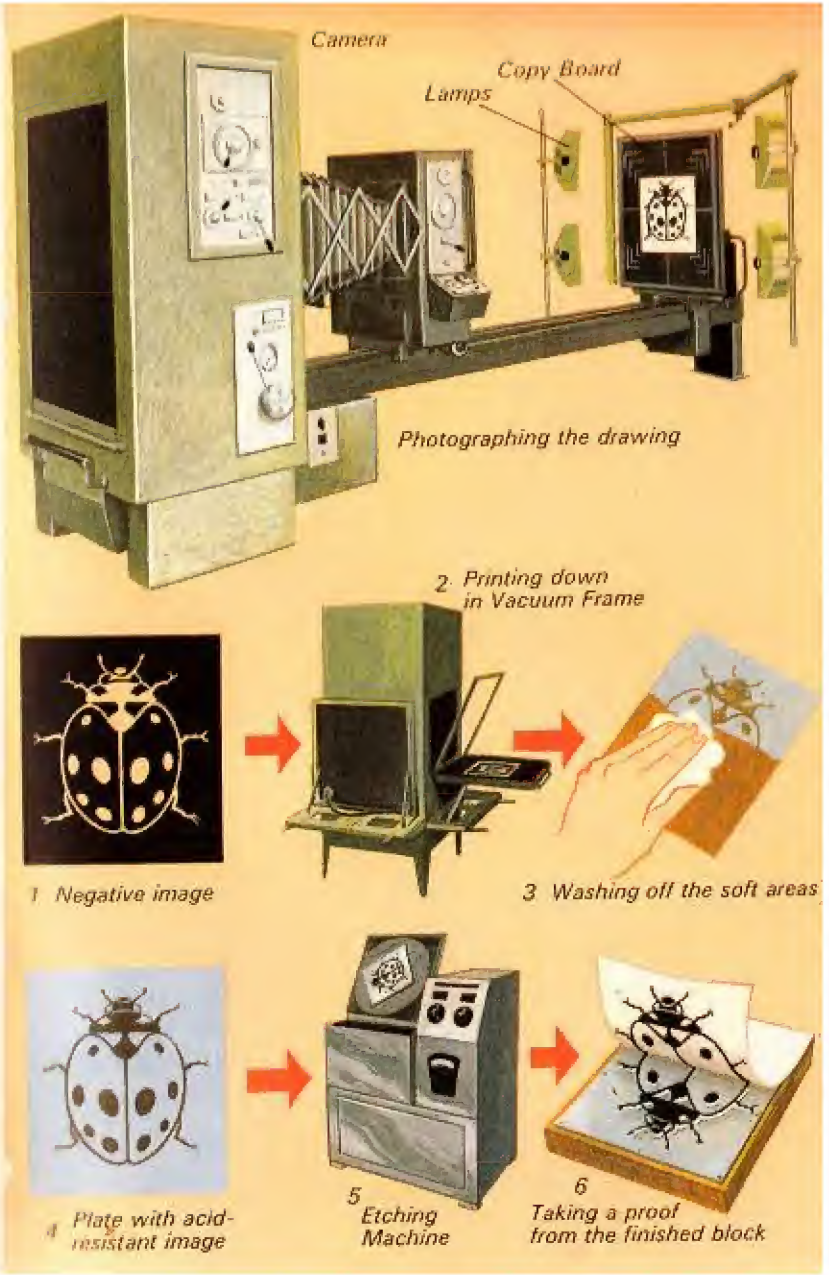
Line reproduction (above).
An enlarged half-tone (below).

Making a Line Block

The drawing from which a line block is made is mounted on a *copy board* which is brightly and evenly lit by arc lamps. Facing the copy board is a large process camera which is mounted on rails so that it can be adjusted backward and forward to obtain the correct focus and to enlarge or reduce the image. A negative image (1) is produced and this is photographically printed down onto a metal plate, normally of zinc alloy treated with a special, light-sensitive solution.

Negative and plate are fixed in a vacuum frame (2) from which all air is excluded to ensure perfect contact. Both are then exposed to a bright light for a pre-set time. Where the light penetrates the lighter areas of the negative and reaches the solution, it hardens slightly. The remaining area of the solution remains soft and is afterwards washed away with water (3). On the zinc plate there is then an image matching that of the negative, the light areas of the negative showing as hardened solution on the plate, and the dark areas as bare zinc alloy (4). The hardened solution is then further hardened by heat which forms an acid-resisting enamel over it.

The plate is then placed in an etching machine containing a bath of acid. Motor-driven paddles splash the acid onto the plate, and the light, unprotected areas are etched away, leaving the enamelled metal printing surface raised above the surrounding metal. From this a proof (6) can be taken.

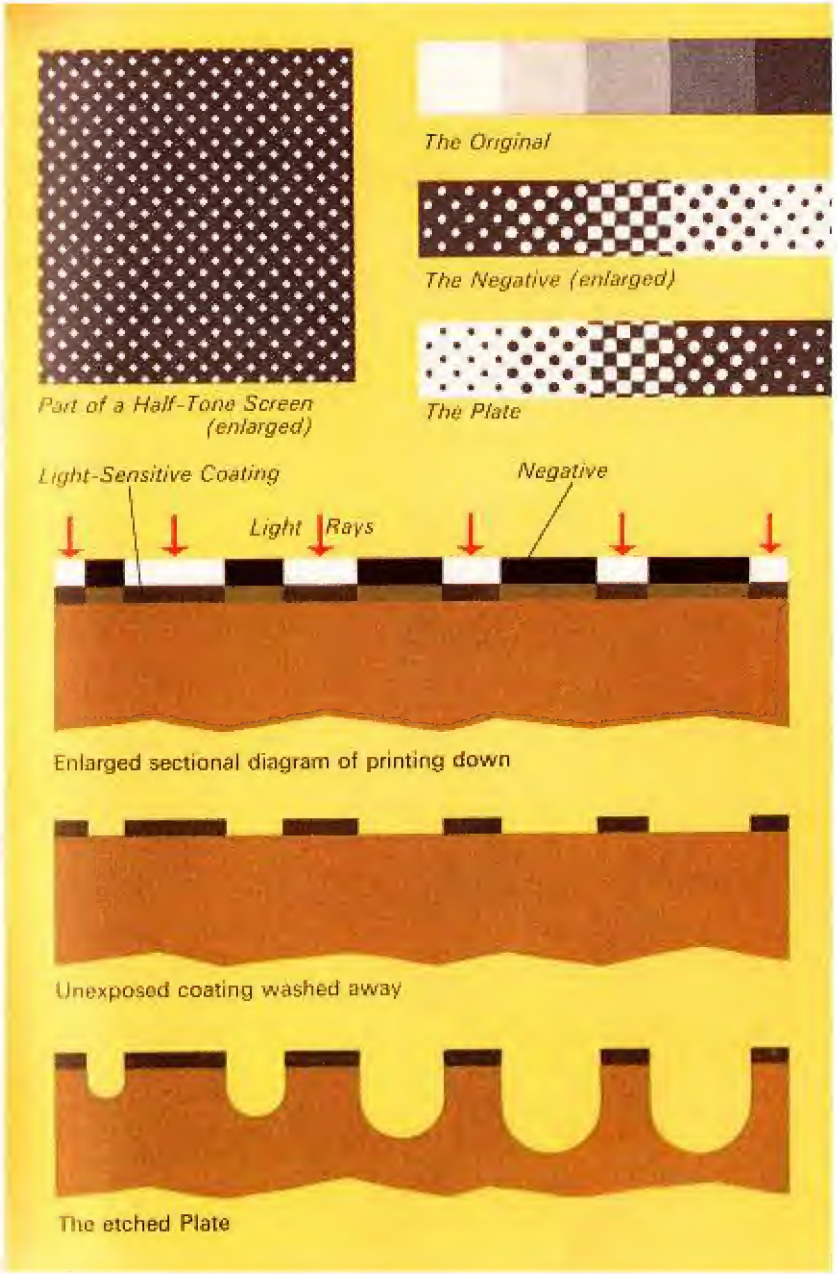


Making Half-tone Blocks

Half-tone blocks are produced in an essentially similar manner to line blocks, the subject being photographed and a negative printed down onto a light-sensitive solution previously applied to a metal plate, which is then etched in acid. In this case, however, the metal is usually copper and the varying tones of the subject have to be reproduced by means of dots.

In fact, the subject is photographed through a glass *screen*. This consists of a circular piece of optical glass on which are drawn a great number of black lines crossing each other at right angles and forming a fine grid. Because the subject is photographed through this screen, the lines of the screen appear on the negative. They appear dense and heavy in the dark areas and as thin lines in the light areas. The negative is printed down onto the sensitized plate, the soft areas of the solution (matching the dark areas of the negative and the screen lines) later being washed away and leaving the hardened areas. When the plate is etched, the thin lines of the screen lose their regular shape and become the raised dots of the half-tone block.

Screens vary in the number of lines drawn across them. A greater number of lines gives a fine screen, less lines gives a coarse screen. Screens of 55, 65, 85, 100, 120 and 133 lines to the inch are common. Poor printing surfaces need coarser screens.



Engraving for Colour

Printing illustrations in their natural colours, instead of black and white, is done by what is called the *four-colour* process. In other words all the colours of the subject have to be produced by four coloured inks only, namely – yellow, red, blue and black.

Half-tone colour blocks – a separate block for each colour – are made in the same way as a black and white one except that a light filter is placed in front of the camera lens so that only one colour is photographed at a time. A violet filter is used to isolate yellow for the yellow negative, a green filter for the red negative and a red filter for the blue negative. A combination filter is used for black, which is really an extra printing to give depth and contrast to the illustration.

To ensure that the four different coloured dots do not print one on top of the other, the screen is rotated a given number of degrees for each colour exposure and the dots print in a circular pattern. Where necessary the white paper shows through the colours to produce highlights and other bright areas.

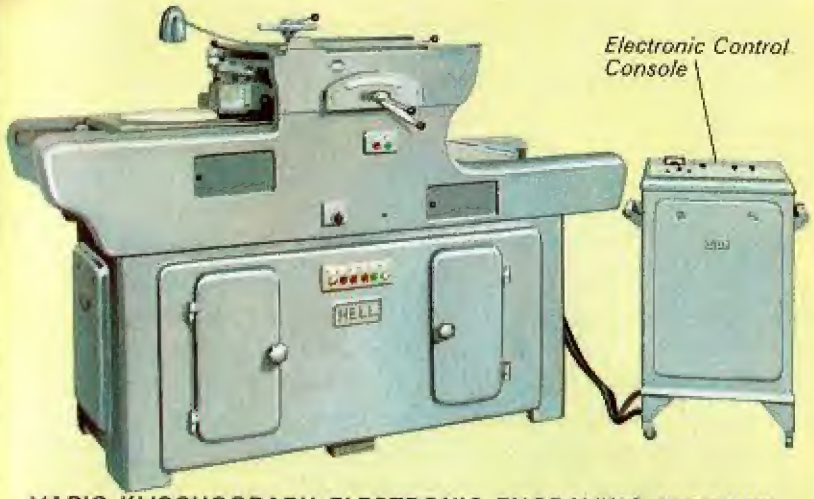
When printing by the letterpress four-colour process, yellow is usually the first colour on, followed by red, blue and black, in that order. The illustrations on the opposite page show the yellow, red and blue printed separately, and the effect produced by printing them together with the black.

Electronic Engraving

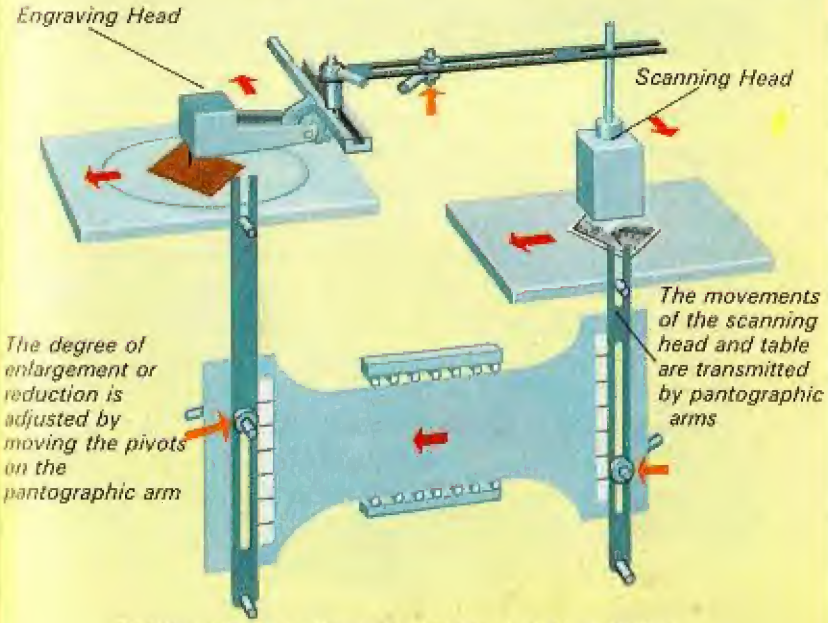
As with almost every other technological process, electronic equipment is being introduced more and more into blockmaking. We will therefore take a quick look at a machine called the *Vario-Klischograph* which makes blocks automatically without negatives and without photographic printing onto metal.

The subject, a drawing or photograph, is held by vacuum onto a glass-topped table and the plate to be engraved is similarly secured to another table. An electronic scanner 'reads' the subject by sweeping a spot of light backward and forward across it. The light is reflected back into the scanner from where it is transmitted onto photo-electric cells which turn the light spots into tiny electric impulses. Greater reflection is provided by the pale areas of the subject, giving a larger impulse. Less reflection is received from the dark areas which produce a correspondingly reduced impulse.

The electric impulses are used to operate an engraving head mounted over the plate. This engraves dots into the plate, the size of the dots varying according to the light and dark areas of the subject as read by the scanner. In this way the engraving on the plate becomes a faithful reproduction of the subject picture. For colour engraving, the light spots are passed through appropriately coloured filters and the plates are rotated for each colour as with the glass screen.



VARIO-KLISCHOGRAPH ELECTRONIC ENGRAVING MACHINE



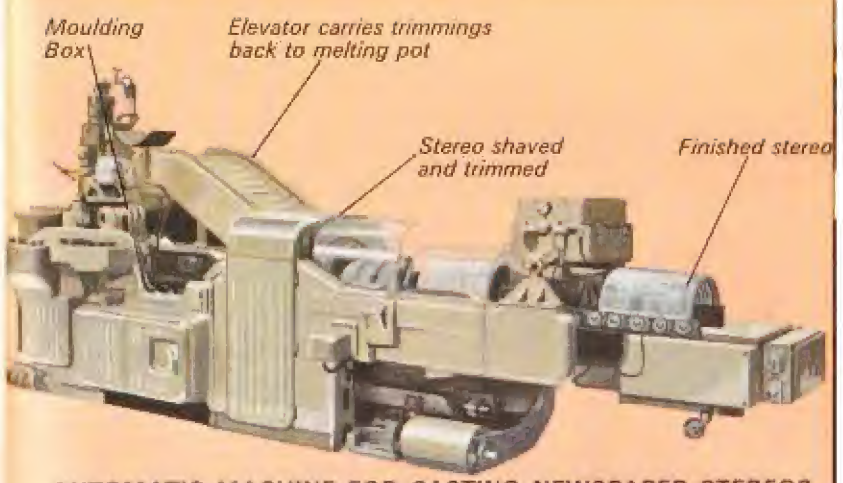
SIMPLIFIED DIAGRAM OF MECHANICAL ACTION

Stereos and Electros

It is sometimes more convenient to print type matter from a block rather than from the type itself, and it may also be necessary to make duplicate copies of these blocks. Duplicates of both type blocks and line blocks are known as *stereos* and the process of obtaining them is *stereotyping*. The method is quite simple. The type forme or block is placed in an electrically heated moulding press and a sheet of plastic is laid over it. The press is operated at a pre-set temperature and timing, and an impression of the type or block is taken by the plastic sheet. This now becomes a mould, or matrix, into which molten metal is poured and the stereo is made. Papier Mâché is sometimes used for matrices and, quite often, stereos are made from plastic or rubber.

Copies of half-tone blocks can also be made. These are produced by a process of *electrotyping* and the copy is known as an *electro*. An impression of the half-tone block is taken in a moulding press. The moulding material can be lead, but plastic *Vinylite* is more common. The mould is then sprayed with an electricity-conducting solution and put into a bath of copper sulphate in which is suspended a copper plate. A low-voltage current is passed through the bath and, by a process of *electrolosis*, copper is deposited from the plate onto the mould. The mould is removed and the hollow back of the electro shell is then filled with molten metal to give it strength.

Pulling a moulded stereo off the matrix. This machine is used for producing matrices for stereos and electros and for moulding rubber or plastic stereos.



AUTOMATIC MACHINE FOR CASTING NEWSPAPER STEREOS

Newspaper stereos are curved to wrap round the cylinders of rotary presses

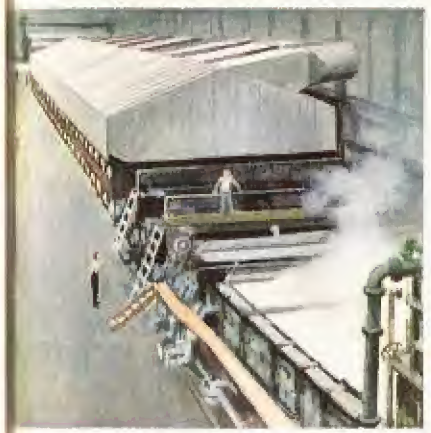
Paper and Ink

Paper is largely made from wood-pulp, although esparto grass from Spain and North Africa is sometimes used for particularly good quality papers. Wet pulp is contained in a tank at one end of a paper-making machine. It enters the machine and flows over a vibrating wire-mesh conveyor which allows most of the water to drain through. The remaining fibres cling loosely to one another and are then passed between rollers which compress them together. After final drying between heated rollers, the paper is wound onto large reels. Different kinds of paper vary in the amount and kind of pulp used and in the pressures applied during rolling. Some kinds are coated with a china clay or plastic solution to give them a fine, smooth printing surface.

Printing inks are not like the inks we use for writing but are of a greasy, paint-like substance which adheres to the paper as a thin film without blotting or running. They can be of any colour for printing separately, one at a time, but for the four-colour printing process the primary colours of yellow, red and blue are specially prepared to a standard colour specification. This enables them to be printed one with the other, and it is the combined effect of these special tones, plus black, that gives a coloured print its natural appearance.

Each log is reduced to 100,000 chips

Digesters turn the chips into pulp



The 'Wet End' of a paper making machine

At the other end - a giant reel of paper

The Standard Printing Ink Colours

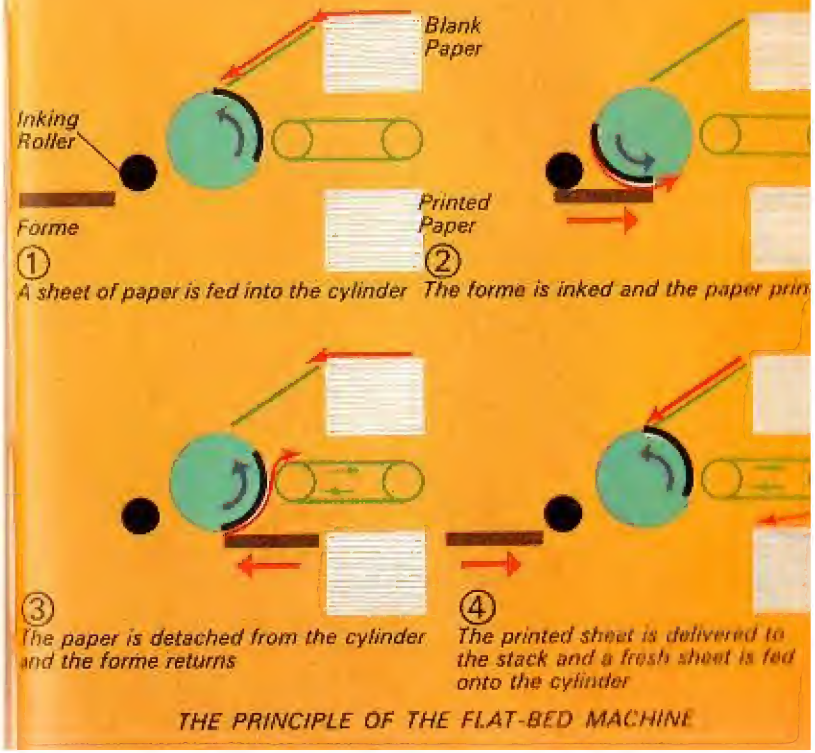
Letterpress Machinery

There are two basic kinds of letterpress printing machine, although it must be said that there are many makes and variations of each kind. There is the *flat-bed* machine which prints from a forme or some other horizontal mounting of type and blocks, and the *rotary* machine in which the printing surface is made in the form of a *wrap-round* plate fitted to a rotating cylinder. Very large versions of the rotary printing press are used in the production of newspapers.

On flat-bed machines the printing forme is fixed to a reciprocating forme bed which travels backward and forward. At one end of its travel it runs under inking rollers which spread the ink evenly over the printing surface. At the other end it comes into contact with the paper onto which the inked impression is transferred.

Paper is stacked in sheets at the feeding end of the machine and is picked up by suction cups, one sheet at a time. It gravitates down a feeder board and on to a rotating cylinder. As the leading edge of the sheet reaches the underside of the cylinder it is pressed into contact with the inked forme and then carries on round the cylinder before detaching itself and moving down a delivery board on to the stack of printed sheets.

FLAT-BED PRINTING MACHINE



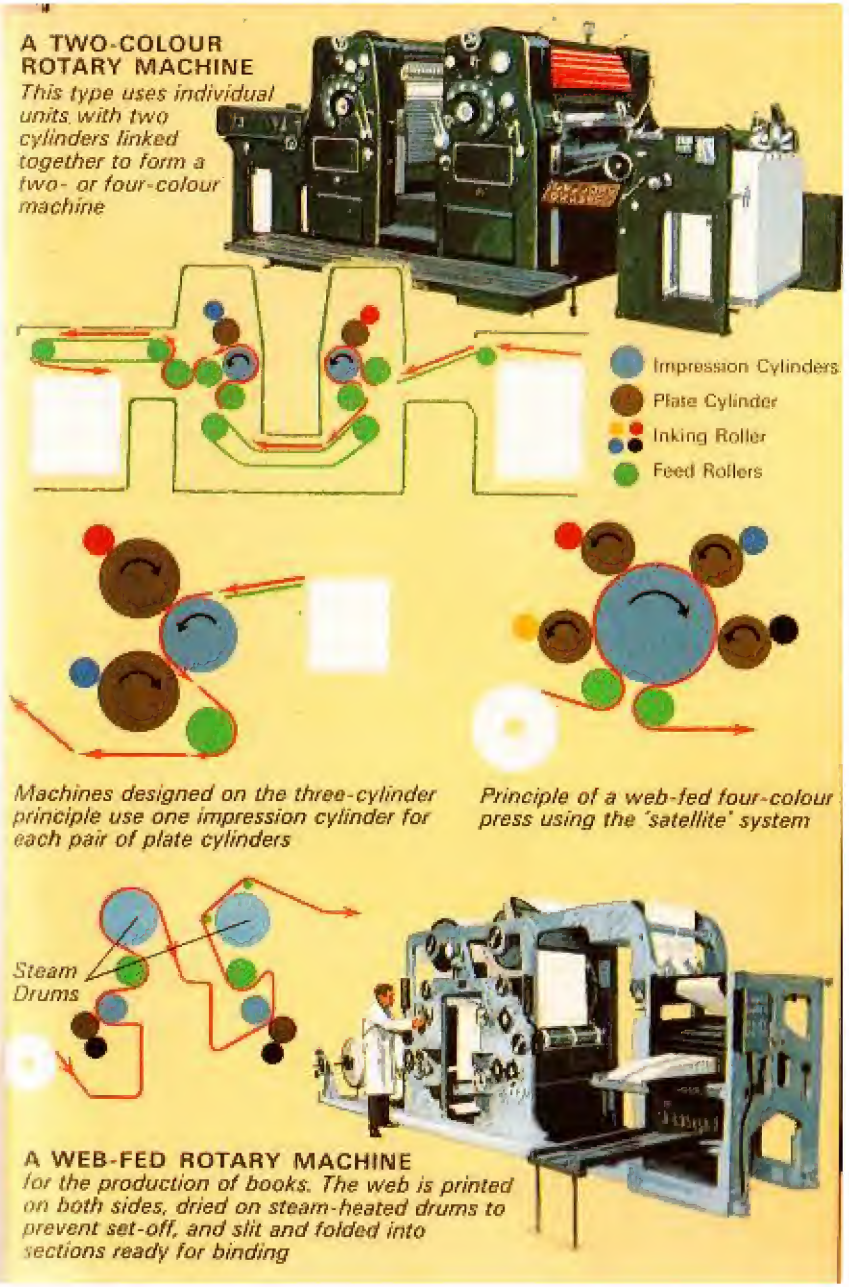
THE PRINCIPLE OF THE FLAT-BED MACHINE

More about Letterpress Machinery

The process outlined on the previous page is simplified in order to give the essential details rather than a description of a particular machine. One point not mentioned is that immediately after a sheet of paper is printed a fine powder is sprayed on the printed surface to prevent *set-off*. This happens if wet ink on one sheet is allowed to mark the underside of the following sheet in the stack.

Colour printing can be done one colour at a time as described, the other colours being added by sending the paper through the same or another machine again for each of the remaining colours. Two-colour and four-colour machines are often used; these print two or four colours in quick succession as the paper is fed through a series of cylinders and over the appropriate number of printing plates. Of course, when the paper has been printed on one side it must go through the machines again so that the reverse side can be printed.

On rotary newspaper presses, there are two cylinders carrying the curved printing plates and two controlling the paper. The cylinders rotate one against the other and the continuous web of paper runs between. Each pair of cylinders prints one side of the paper which is thus printed on both sides at once.



The Lithographic Process

So far we have dealt almost exclusively with the various aspects of letterpress printing, but in doing so we have gained a good deal of information on printing in general. We must not get the idea that letterpress is the only process or necessarily the most important one. This book, for instance, is printed by photolithography as are all Ladybird books and a great many different kinds of other publications as well.

Litho printing is done from a very thin metal plate, usually made of zinc and aluminium, which can be bent to fit round a printing cylinder. Because this form of printing uses a flat, or very slightly recessed surface, a means has to be found of confining the ink to the image areas of the plate and keeping it away from the non-printing portions. Without some such method the rollers would simply cover the whole plate with ink and the result would be a terrible mess.

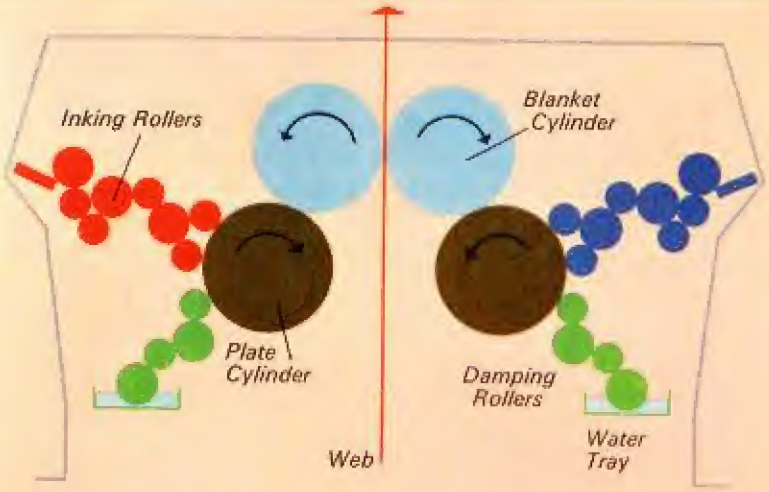
The system depends on the actions of two natural enemies – grease and water. A greasy substance is applied to the areas to be printed, and the non-printing areas (which have a very finely-grained surface) are dampened with water. A very fine film of water is retained by this grained surface. The greasy printing ink adheres to the greasy image but is rejected by the water on the dampened part of the plate which therefore remains clean and does not mark the paper.

The four-colour offset litho machine that printed this book. Sheets making two complete Ladybird books are printed in a double journey through the machine, four colours in quick succession on each side of the sheet.

Photolitho and Offset-litho Printing

Litho printing plates are produced photographically by making a negative image of the subject; it might be typematter or illustrations or both. The illustration negative is then photographed through a screen and a positive screened image is produced on film. Alternatively, the positive film can be produced by the Vario-Klischograph described on page 28 and other similar machines. This film is then exposed onto a light-sensitive plate. The printing image thus produced may be left flat or lightly etched into the metal with acid. Unlike a letterpress block, the image on a litho plate is the right way round. This is because the plate does not print directly on the paper as in letterpress. The impression is first transferred, or *offset*, onto a cylinder carrying a rubber *blanket*, and from there onto the paper. This process is known as offset-litho and is the one now universally adopted. It gives a softer appearance to the printed picture than letterpress, it can be used on less-expensive, non-coated papers and is suitable for long printing runs without the plates wearing out.

Litho colour printing, which can be in line or half-tone, requires a separate plate for each colour. Multi-colour presses are frequently used. One model, called the Web Offset machine, prints four colours in quick succession and on both sides at once of a continuous web of paper fed from reels. The AA magazine 'Drive' is printed on a press of this kind as are several other colour magazines.



THE PRINCIPLE OF A WEB OFFSET MACHINE

A WEB OFFSET LITHO MACHINE

SYMBOLS FOR PROOF CORRECTION

The marginal mark shows the correction to be made. The textual mark indicates the location of the correction.

Instruction	Textual mark	Marginal mark
Insert matter indicated in margin		
Delete and leave space or insert space	Strike through letters, etc., to be deleted	
Leave as printed	- - - under letters or words to remain	stet
Change to italic	—— under letters or words to be altered	ital
Change to capital letters	≡ under letters or words to be altered	caps
Change to bold type	~~~ under letters or words to be altered	bold
Change to lower case	Encircle letters to be altered	l.c.
(Wrong fount.) Replace by letter of correct fount	Encircle letter to be altered	w.f.
Invert type	Encircle letter to be altered	
Change damaged letter(s)	Encircle letter(s) to be altered	

Instruction	Textual mark	Marginal mark
Close up—delete space between letters	⁀ linking words or letters	
Insert space		#
Insert space between lines or paragraphs	None	# >
Move matter to right	⊏ at left side of group to be moved	
Move matter to left	⊐ at right side of group to be moved	
Raise lines	⊼ over lines to be moved	raise
Lower lines	⊻ under lines to be moved	lower
Substitute or insert comma	/ through character or where required	,/
Substitute or insert full-stop	/ through character or where required	⊙
Insert parentheses	/ or	(/)/
Insert hyphen		/-/